

Teaching Framework, Goals, Objectives, Assessment and Addressing Diversity for a Unit on Chemical Equilibrium

in a Synergistic Introductory Course in Chemistry and Physics

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Teaching Framework for the unit

Learning Goals	Learning Objectives	Activity	Assessment	Diversity
What will students know, and/or understand at the end of this tidbit?	What will students be able to do (learn, value and/or produce)? Think about specific performances that will indicate achievement of the goals.	What activities will engage a diversity of students in learning and achieving the goals? Briefly describe the activities and identify which methods of active learning you intend to utilize.	How will you, the instructor, and the students gauge learning throughout the tidbit?	How will you engage all students in the activity? How will you foster an inclusive learning atmosphere?
Concepts : <i>Basics science of fuel cell/battery operations</i> <i>Introductory concepts</i> <i>Chemical Oxidation</i> <i>Chemical Reduction</i> <i>Potential Difference (Voltage)</i> <i>Current</i> <i>Resistance</i> <i>Kirchoff's Laws</i> <i>Chemical Equilibrium and Non-equilibrium Conditions</i> <i>Chemical Equilibrium</i> <i>Chemical potential:</i> <i>Electrochemical series</i> <i>Nernst Equation</i> <i>Applications</i> <i>Circuit example:</i> <i>Kirchoff's Laws</i> <i>Ohm's Laws</i> <i>[Series/parallel]</i> <i>Thermodynamics of Galvanic [energy-producing]</i> <i>electrolytic processes</i> <i>[energy consuming]</i>	Learn: Qualitatively describe chemical equilibrium Characterize and assess an electrochemical process given a set of parameters such as an electrochemical series, or the Nernst Equation [Draw a battery showing solutions/salt bridge/separator] Assess the performance of energy-producing cells in series and in parallel. List advantages and disadvantages in order to evaluate which is best. Work on the same example with lightbulbs. [Energy consumers]Assess the performance of energy-consuming systems such as lightbulbs.	<i>Handouts with material will be provided for pre-class reading.</i> Student competition: Teams of 4 Open Book/Computer. Premise: you are on a relaxing vacation on Venus and your spaceship breaks down. But it's your lucky day! You have metals all around you and you've taken this class! K, Zn, Cr, Cd, Fe, Zn and Au are at your disposal. [T on Venus is 460 °C] You need 220V. [You have a coolant device that can operate with sunlight and keep your water reserves at 80 °C in liquid form] Design a cell [that you can carry]. How many cells do you need? How much material do you need? Can you get that much? Describe the circuit and composition. Should your system be in series or in parallel? Can you save the day?	Specific assessment details below Class discussion – team feedback forms. Concepts learned are then applied. Self-assessment and peer assessment within the group.	Teamwork. Think/Pair share. Dyad.

a. Meaning of symbols

[Goals]	Introduce symbols, allow students to understand their use.
[Objective]	Students get an idea of qualitative and quantitative understanding.
[Activity]	Measurements and observation of phenomena. Introduction to units. <i>5 min lecture</i> – letters and numbers to designate quantities and descriptors of measurements. C a t <- to allow us to talk about a cat without having a cat present. C h a t <- If you were born and raised in France <i>Think pair share</i> <i>Car vs. Toy car. Descriptors of observables.</i> 5 min lecture: Volume, length, area: tennis ball vs Jupiter. Introduction to simple SI units and order of magnitudes and interconversions.
[Assessment]	One minute essay about toy car vs. real car. Descriptors.
[Diversity]	teamwork

b. Chemical Symbols.

[Goals]	Define element symbols- just a collection of three types of particles. Intro to the periodic table
[Objective]	Allow the students to understand the structure atoms and where they can look it up.
[Activity]	1. Short lecture in class. Types of particles. Charge (C). Ask the students if they are familiar with any chemical elements. <i>Iron Bar, Helium Balloon, Argon Balloon.</i> 2. Ask students in the class to claim an element and a substance that element is part of. <i>Student dyad- Compare similarities/differences between partners.</i> <i>Flip classroom: Have everybody give a presentation about their partner's element and substance.</i> <i>Ask the students to use: http://phet.colorado.edu/en/simulation/build-an-atom to guide their answers</i> 3. Short lecture on Chemical Substances. <i>http://phet.colorado.edu/en/contributions/view/3468</i>
[Assessment]	Student must talk to a randomly assigned person in the class. <i>One minute essay about the element they were and their partner's element.</i>
[Diversity]	Randomized student work.

c. Introduce Equilibrium in a Qualitative Sense

[Goals] Students should develop a qualitative sense of what equilibrium is

[Objective] Help students to relate to mechanical equilibrium, which they can see!

[Activity]

1. Ask the students why we care about this.

Expected answer- because it's everywhere.

2. Lecture: Short example of tug-of-war, teeter-totter. Guy on bicycle. Atom neutrality.

Moving to and from equilibrium conditions.

Think pair share

Ask students what to give anonymous, written examples of other equilibria and what they think equilibrium is.

Identify misconceptions.

[Assessment] Assign a group project (groups of 3)- ask them to pick a type of equilibrium.

Next class period, class discussion, group presentation. Ask why that type of equilibrium is important.

[make sure someone picks any kind of specific chemical and/or biological equilibrium]

[Diversity]

Foster creativity and open discussion.

d. Electrons

[Goals] Illustrate Atomic Structure and Changes in the Electronic Configuration upon Loss and Gain of e^-

[Objective] Intro to redox chemistry. Oxidation/ reduction.

[Activity]

1. Meaning of words.

One-minute question 1. What does oxidation/ reduction mean when presented with just the words.

Expected responses: Oxidation- has to do with oxygen, maybe. Reduction – something gets tiny.

One-minute question 2. What is a “reaction”? Hwk: look up dictionary term definitions. Discuss.

One minute question 3. What is an “equation”? Hwk: look up dictionary term definitions. Discuss.

One minute question 4. What does balancing a reaction mean? Hwk: look up dictionary term definitions. Discuss.

2. Lecture:

Atomic structure- Protons+ neutrons in the nucleus, electrons outside in a cloud compensating for the charge
Chemical Oxidation and Reduction: Transfer of electrons to and from an atom.

Balancing a chemical equation!

M^0 - atoms in native state, full electron shell

$M^+ \rightarrow M^0 - 1e^-$ When you lose an electron, the charge on the atom increases by 1 unit

Atom gets oxidized

$M^0 \rightarrow M^{+} + 1e^-$ When you gain an electron (Payday!), the charge on the atom decreases by 1 unit

Atom gets reduced

Assigning oxidation states. Work through a couple of examples.

Redox balancing of an equation. Example.

You need to account for both # of atoms and redox states when you **balance** an equation!

“Agents always help another party” [<http://www.simplechemconcepts.com/page/82/>]

i.e. Property Agents – help another party to get property

i.e. Insurance Agents – help another party to get insurance coverage

i.e. Oxidising Agents – help another substance to get oxidised

i.e. Reducing Agents – help another substance to get reduced

[Assessment]

1. One minute essay: You're a Cu atom and you lost your electrons. What kind of agent are you?



2. Emphasize molecules are neutral. Assign oxidation states of elements in a substance. Homework.

3. Student dyad. Introduction to the concept of a chemical equation. What is a chemical reaction?

Balancing an equation [meaning of words- how does that tie in with equilibrium].

Ask the groups to debate in-class.

4. Can't have reduction without oxidation. Redox balancing of an equation. Homework.

e. Chemical Potential

[Goals] Students develop an understanding of what potential is.

[Objective] Introduce the student to the electrochemical series and chemical potential.

[Activity]

1. In-class question. Meaning of words. What does potential mean?

Merriam-Webster definitions:

“- existing in possibility : capable of development into actuality <*potential* benefits>

- expressing possibility; *specifically* : of, relating to, or constituting a verb phrase expressing possibility, liberty, or power by the use of an auxiliary with the infinitive of the verb (as in “it may rain”)

If you were living 2000 years ago, you would be familiar with the Latin *potentialis*, from *potentia* potentiality, from Latin, power, from *potent-*, *potens*.”

Discussion.

2. Lecture. Voltage- measurement of electrical AND chemical potential (V).

Introduction to work. In-class question: What is it caused by?

3. Lecture. In-class question: What happens when electrons are moving around? Tie back to charge from intro part.

Introduction to current and Amperes. Example of a half-cell reaction and potential.

Electrochemical series [learn how to read and interpret it].

Standard Reduction Potentials. Electrode signs.

4. Lecture. Ohm’s law. Resistance. Qualitative analogy with friction. Tie in with unit on Mechanical Equilibrium.

[Assessment]

Pre-class Group Project- meaning of words.

1. Brainstorming 1. When I say voltage- what comes to mind? Examples.

2. Brainstorming 2. When I say resistance- what comes to mind? Examples.

3. Brainstorming 3. When I say current- what comes to mind? Examples.

4. Brainstorming 3. When I say power- what comes to mind? Examples.

5. Watch <http://www.youtube.com/watch?v=J4Vq-xHqUo8>:

Graded Assignment- How does a light bulb work? Does it consume or produce power? Short Research project.

[Diversity]

6. Student dyad. Why does a copper penny dissolve in nitric acid and not in hydrochloric acid? Explain by discussing balanced chemical reactions.

“http://www.answers.com/Q/Why_does_copper_dissolve_in_nitric_acid_but_not_in_hydrochloric_acid”

e. Kirchoff's Laws

[Goals] Students become familiar with parallel and series DC circuits.

[Objective] Allow the students to discover how series and parallel circuits work.

[Activity] Using the phet.colorado.edu in class, we are going to build a series and parallel circuit in class and look at current, potential, resistance with two-three lightbulbs. Differences between brightness of lightbulbs between series and parallel.

[Assessment]

1. Student Dyad. You're super excited about your new Christmas lights. They're not working. Why do you think that could be?

2. Individual homework. Using the phet.colorado.edu circuit building tools, build a circuit that can provide 200W.

[Diversity] dyad.

f. The Nernst Equation: Non-equilibrium Condition

[Goals] Tie in the concepts of chemical potential, redox equilibrium and deviations from it. Electrolysis vs. Galvanic piles. Electromotive force.

[Objective] Be able to understand and apply the Nernst Equation to determine the EMF of a cell.

[Activity] **1. Lecture.** Sketch a cell and explain how it works. Ask the students to bring a copy of the electrochemical series (ES).

Bring an in-class example. Introduce Gibbs Free Energy and Electromotive Force.

2. Redox Equilibrium and Deviations from it. Write out the reactions of the chemical components. Balance them. Determine the E^0 with the data from ES. Use the Nernst Equation to determine the expected Voltage out.

Have a couple of $\text{Zn}/\text{Zn}^{2+}||\text{Ni}^{2+}/\text{Ni}$ cells in class. Use a voltmeter to allow the students to measure the voltage in class.

Switch the voltmeter leads. Explain the sign of the voltage changing.

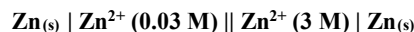
Introduce galvanic (Sources) vs. electrolytic cells (Consumers).

[Assessment] | <http://www.science.uwaterloo.ca/~cchieh/cact/c123/nernsteg.html>

Group homework-work in pairs. Come to class and present your answers. Class discussion/debate.

1. In making a specific galvanic cell, explain how one decides on the electrodes and the solutions to use in the cell.

2. Calculate the EMF of the cell



3. Show that the voltage of a cell is unaffected by multiplying the reaction equation by a positive number. ($\text{Al} \mid \text{Al}^{3+} \parallel \text{Ag}^+ \mid \text{Ag}$) Is this galvanic ?

4. Using phet.colorado.edu work with a partner to put together a circuit made of piles and electrolysis cells to provide 100V to a consumer. Explain the chemical composition, reactions at each electrode of the cells used. Write down and explain your work.

[Diversity] Group work.

Summative assessment for the unit

Premise- you are on a relaxing vacation on Venus and your spaceship breaks down. Oh NO!

But it's your lucky day! You have metals all around you and you've taken this class!

K, Zn, Cr, Cd, Fe, Zn and Au are at your disposal. [T on Venus is 460C but, you have a coolant device that can operate with sunlight and keep your excessive water reserves at 80C in liquid form]

You need 220V to get your spaceship going.

Design a cell [that you can carry] -> how many do you need?

How much material do you need, can you get that much? How are you going to connect the cells?

Describe the circuit and composition series/parallel? You are welcome to use any resource available to you.

Written team report/team interview.

Students submit an assessment for each of the team partners with detailed contributions for each of the team members and a corresponding grade for each of the members' contribution.

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